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Nutritional value of edible wild mushrooms collected from the Khasi hills of Meghalaya

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Abstract

Seven wild edible mushrooms commonly consumed in the Khasi hills of Meghalaya were analyzed for their contents of dry matter, crude protein, fat, fibre and ash along with minerals (Ca, P, Fe, Mn, Cu, Zn, Na, K, Mg and Se), ascorbic acid and the profile of essential amino acids. The macronutrient profile in general revealed that the wild mushrooms were rich sources of protein and had low amounts of fat. In general, most of the mushrooms studied had good amounts of minerals, including trace minerals. On average, phenylalanine was the limiting amino acid (0.9 μg%) while the highest amount of EAA present in the mushrooms studied was leucine (704 μg%). One serving of the studied mushrooms (250 g fresh weight) contained an average of 6.12 g of protein, 287 mg of calcium, 9.3 mg of iron and 3.72 mg of zinc. More importantly it had low levels of fat (0.712 g) and sodium (0.077 mg).

Keywords: Mushrooms; Nutrients; Amino acids; Khasi tribes

1. Introduction

The consumption of wild edible mushrooms is increasing, even in the developed world, due to a good content of proteins as well as a higher content of trace minerals (Thimmel & Kluthe, 1998). Wild mushrooms are a popular food source among the Khasi tribe of Northeast India. The region is a high rainfall area and boasts some of the wettest areas of the world. The high humidity level during the monsoon season (June–October) provides ideal atmospheric conditions for the growth of many saprophytes, including the mushrooms. There are several wild mushrooms that grow in the forests of Meghalaya and the locals relish them. The mushrooms are picked from the forest and they form an integral part of the diet during the monsoon months when these are abundantly available. In spite of the immense popularity of this food in the region, data regarding the nutritive value of the wild mushroom varieties available in the region are very meagre. The present study determines the nutritional content of the commonly consumed wild mushrooms found in Meghalaya.

2. Materials and methods

2.1. Identification and collection of the wild mushrooms

Seven unconventional mushrooms eaten by the Khasi tribals were identified with the help of a rapid rural appraisal survey (Agrahar-Murugkar & Pal, 2004) and these were collected from the forests and markets of the East Khasi hills (Fig. 1). The mushrooms were scientifically identified at the National Bureau of Plant Genetic Resources, ICAR, Barapani, Meghalaya and Botanical Survey of India, Shillong, Meghalaya, India.

2.2. Sample preparation

Mushrooms from the forest were first washed thoroughly to free them from mud, ferns and other extraneous material, dried on blotting paper, cut into pieces

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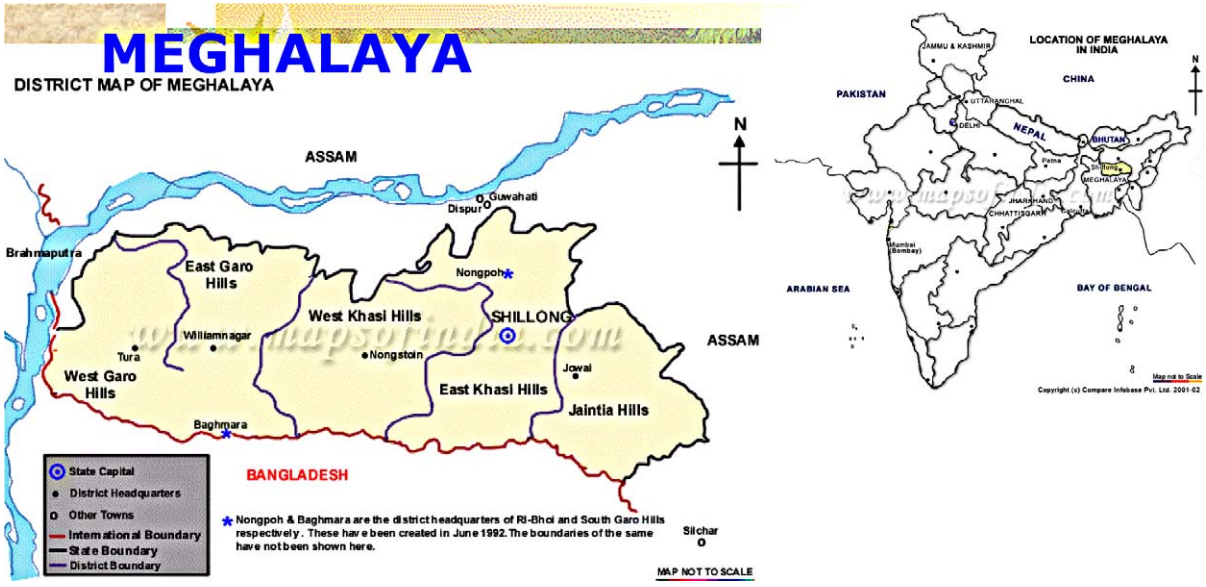

Fig. 1. Map of Meghalaya.

and dried at 60 °C. The mushrooms selected are normally harvested for consumption without division into pileus and stipe. Therefore the whole mushrooms (pileus + stipe) were dried, ground to a fine powder (to pass through a 40 mesh sieve) and stored under vacuum for further analysis. Since the shelf life of the mushrooms is very short, these were analyzed for vitamin C on the same day that the samples were collected.

2.3. Analyses

All the analyses were carried out in triplicate to ensure replicability of the results.

2.4. Macronutrients

The crude protein content of the samples was estimated by the macroKjeldhal method (AOAC, 1990), in which the sample was digested with a known quantity of acid in the KelPlus digestion apparatus (Pelican Equipments, India). The digested material was distilled after the addition of alkali. The released ammonia was collected in 4% boric acid in the KelPlus Automatic Distiller (Pelican Equipments, India). The resultant boric acid, which now contained the ammonia released from the digested material, was then titrated against 0.1 N HCl, manually. The nitrogen content thus determined was multiplied by a factor of 6.25 to arrive at the amount of crude protein (Raghuramulu, Nair, & Kalayanasundaram, 1983). Fat in the samples was determined by extracting a known weight of powdered plant sample with petroleum ether, using the Labconco (Germany) ether extract apparatus (AOAC, 1990). Crude fibre was determined by acid and alkali digestion methods, using KelPlus Fibre tech apparatus (Pelican Equipments, India) on the fat-extracted sample (Raghuramulu et al., 1983). The ash content was determined by combusting the plant material in silica crucibles in a muffle furnace at 620 °C for 3 h (AOAC, 1990).

2.5. Minerals

The ash obtained after combustion in the muffle furnace was used to prepare the ash solution, which was in turn used for the estimation of calcium and phosphorus. Calcium was precipitated in acidic medium as insoluble calcium oxalate by adding saturated ammonium oxalate solution. The precipitate was dissolved in dilute sulphuric acid (1:9), heated and the oxalic acid thus released was titrated against standard potassium permanganate solution, in warm condition (60 °C), to get the calcium content of the sample (Raghuramulu et al., 1983). Phosphorus was determined spectrophotometrically, using the Vendate's solution (AOAC, 1990).

The micronutrients (Fe, Cu, Zn, Mn, Mg, Se) were determined by an atomic absorption spectrophotometric (AAS) method. The samples, which were digested in a tri-acid solution of H_2SO_4, HCl and HNO_3, were passed through the AAS system using different lamps and, calibrated for different micronutrients. Potassium and sodium was determined by flame photometer after tri-acid digestion (AOAC, 1990).

2.6. Vitamins

Ascorbic acid was determined by a reduction method using a dye (2,6 dichlorophenol indophenol), which turns blue in alkaline solution and red in acid solution,

and is reduced to colourless by ascorbic acid (Raghuramulu et al., 1983).

2.7. Essential amino acids

Defatted mushroom samples were hydrolysed at 110 °C for 22 h with 6 N (constant boiling) hydrochloric acid in evacuated sealed ampoules. After hydrolysis, the excess acid was removed by flash evaporation under reduced pressure. Amino acid analysis was carried out by ion-exchange chromatography in an automatic amino acid analyzer (Beckman 119-C, Beckman Instruments, Fullerton, CA) (Moore, Specman, & Stein, 1958).

3. Results and discussion

3.1. General

We studied the nutritional content of the seven wild mushroom species, which were regularly consumed by the Khasis. The nutritional content, especially the trace minerals and amino acid contents of most of these mushrooms were not reported previously and none of the mushroom species were commercially grown. Some of the mushroom species, such as *Calvatia gigantean*, *Cantharellus cibarius*, *Russula integra*, *Gomphus floccosus* and *Lactarius quieticolor*, were easily identifiable by the Khasi tribals and hence were collected with ease from the nearby forest in the region. However, others, such as *Clavulina cinerea* and *Ramaria brevispora*, were collected by specialist collectors and were procured from the local markets. The mushrooms were normally found between July and September during the peak monsoon season. All of the mushrooms selected grew on dead wood on the ground in the forests under shade.

3.2. Macronutrient profile

The dry matter ranged from 4.7 g% in *C. gigantea* to 15.9 g% in *C. cibarius*. Protein contents were generally high and varied between 19.0 g% in *L. quieticolor* to 27.5 g% in *C. cineria.* Fat ranged from 1.0 g% in *C. gigantea* to 5.3 g% in *G. floccosus*. Fibre ranged from 8.4 g% in *C.cineria* to 22.2 g% in *C. gigantea*. Ash content varied between 6.3 g% in *C. gigantea* to 13.9 g% in *C. cinerea*. The macronutrient profile, in general, revealed that the wild mushrooms were rich sources of protein and had low amounts of fat (Table 1) making it an ideal snack material. This high protein and low fat characteristic of the edible wild mushrooms has been previously reported by many workers (Aletor, 1995; Diez & Alvarez, 2001; Longvah & Deosthale, 1998).

3.3. Micronutrient profile

The micronutrient profile, in terms of minerals and vitamin C, is given in Table 2. Of the 7 wild mushrooms analysed, the calcium (g%) content ranged from 0.42 in *C. cibarius* to 1.91 in *C. cineria.* Phosphorus (g%) levels were the highest in *C. cibarius* (0.58), followed by *R. brevispora* (0.51) whereas *R. integra* had the lowest levels with 0.24. *C. cinerea* had a very high content of iron (mg%) at 75.2. The rest fell in the range 7.17 (*R. brevispora*) to 56.2 (*R. integra*). Manganese (mg%) levels ranged between 4.41 in *C. gigantea* to 11.4 in *R. brevispora.* The copper (mg%) of the mushrooms studied was between 1.39 (*C. gigantea*) and 23.9 (*C. cinerea*). Zinc (mg%) levels varied between 6.76 in *R. brevispora* and 39.4 in *L. quieticolor*. A similar range for calcium, phophorus, iron, manganese, copper and zinc has been reported for popular wild edible mushrooms from Northern Thailand (Sanmee, Dell, Lumyong, Izumori, & Lumyong, 2003) where the climatic conditions are similar to Meghalaya. Sodium (mg%) ranged from 0.14 in *G. floccosus* to 0.56 in *R. integra.* The concentration of sodium is relatively low and is of very great nutritional benefit to the consumer, a finding that has been corroborated by Vetter (2003). Potassium levels varied between 17.0 (*L. quieticolor*) and 52.1 (*C. cinerea*). Magnesium (mg%) content was between 25.3 in *L. quieticolor* to 327 in *R. virescens*. The level of magnesium reported in this study was relatively high compared to earlier published reports (Aletor, 1995; Demirba, 2001). There was a wide variation in the content of selenium (μg/kg), beginning at negligible levels in *G. floccosus* to

Table 1
Macronutrient profile (g%) of selected mushrooms

S. no.	Scientific name	DM%	Protein	Fat	Fibre	Ash
1	*C. gigantea*	4.37	27.3	1.0	22.0	6.3
2	*C. cinerea*	13.0	27.5	2.5	8.4	13.9
3	*C. cibarius*	15.9	21.1	1.6	12.8	13.2
4	*R. brevispora*	10.5	24.1	1.3	8.8	10.9
5	*R. integra*	9.7	21.1	4.5	6.4	11.5
6	*G. floccosus*	13.0	21.2	5.3	9.2	8.0
7	*L. quieticolor*	8.2	19.0	2.6	14.4	6.6
	Average	10.7	23.0	2.68	11.7	10.1

Values are expressed on dry weight basis.

Table 2
Micronutrient profile of selected mushrooms

S. no.	Botanical name	Ca[a]	P[a]	Fe	Mn	Cu	Zn	Na	K	Mg	Se[b]	Vitamin C (mg%)
1	*C. gigantea*	0.63	0.33	10.7	4.41	1.39	10.3	0.18	22.3	150	91.2	14.9
2	*C. cinerea*	1.91	0.42	75.2	6.79	23.9	11.1	0.33	52.1	43.8	0.17	41.8
3	*C. cibarius*	0.42	0.58	53.5	7.68	4.36	6.83	0.29	47.9	46.2	295	41.9
4	*R. brevispora*	0.53	0.51	7.17	11.4	16.7	6.76	0.31	35.5	217.2	5.28	28.0
5	*R. integra*	1.27	0.24	56.2	7.28	3.33	10.5	0.56	41.0	327	26.9	19.6
6	*G. floccosus*	1.37	0.34	22.3	7.04	3.48	13.0	0.14	18.7	136	*X*[c]	25.8
7	*L. quieticolor*	1.46	0.42	19.4	5.32	1.41	39.4	0.21	17.0	25.31	975	18.1
	Average	1.08	0.41	34.9	7.13	7.8	14.0	0.29	33.5	135	199	27.2

Values are expressed on dry weight basis.
[a] Ca and P in g% and the rest of the minerals in mg%.
[b] Selenium in μg/kg.
[c] (*X*) stands for negligible quantities.

Table 3
Essential amino acid profile of selected mushrooms

S. no.	Botanical name	EAA μg/100 g								
		Hist	Thr	Arg	Val	Meth	PHE	Iso-leu	Leu	Lys
1	*L. quieticolor*	35.2	80.2	85.7	41.9	67.2	0.1	71.7	4611	24.6
2	*C. cibarius*	50.0	19.7	12.2	71.2	12.2	0.3	0.6	0.4	17.1
3	*C. cineria*	21.0	70.9	0.5	0.6	124	0	25.7	248	1.4
4	*G. floccosus*	12.0	17.7	13.9	10.5	57.2	0.2	5.0	22.7	14.3
5	*C. gigantea*	0	0	*X*	5.7	0	0	0	0	0.2
6	*R. brevispora*	4.3	24.6	16.3	*X*	16.2	5.4	0.2	22.3	39.8
7	*R. integra*	8.4	12.8	12.4	7.9	43.1	0.3	6.3	25.7	16.9
	Average	18.7	32.3	20.1	19.7	45.8	0.9	15.6	704	16.3

Values are expressed on dry weight basis.

very high levels in *L. quieticolor* (975) and *C. cibarius* (295). In general most of the mushrooms studied had good amount of minerals including trace minerals.

The vitamin C content (mg% on dry matter basis) was determined in the mushrooms and ranged from 14.9 in *C. gigantea* to 41.9 in *C. cibarius*. The amounts of ascorbic acid found in some of the species examined were much higher than the amounts found in conventional mushrooms, where the ascorbic acid contents vary from 13.0 to 14.7 mg/100 g in various mushroom sporophores (Zakia, 1976).

The essential amino acid profiles (μg%) (Table 3) showed that *C. gigantea* had the lowest amounts of all the amino acids studied. *L. quieticolor* on the other showed high amounts of most of the amino acids, such as histidine (35.2), threonine (80.2), arginine (85.7), valine (41.9), methionine (67.2), iso-leucine (71.7), leucine (4610.9) and lysine (24.6). Apart from this, *C. cibarius* had good amounts of histidine (50.0) and valine (71.2) and *C. cineria* had good amounts of threonine (70.9), methionine (124) and leucine (248). On average, it was observed that phenylalanine was the limiting amino acid (0.9 μg%) while the highest EAA present in the mushrooms studied was leucine (704 μg%). The average range for essential amino acids was between 16.3 (lysine) and 45.8 μg% (methionine). Though the concentrations of essential amino acids were much smaller than those of egg and milk, they were comparable to vegetables (Gopalan, Ramasastri, & Balasubramanian, 1998).

On the whole, the mushrooms studied were found to be a good source of protein, fibre and trace minerals. One serving of the studied mushrooms (250 g fresh weight) contained an average of 6.12 g of protein, 287 mg of calcium, 9.3 mg of iron and 3.72 mg of zinc. More importantly they had low levels of fat (0.712 g) and sodium (0.077 mg) making them ideal components of the diet of obese, hyper-cholestrolemic and hypertensive persons.

4. Conclusion

The varieties of mushrooms consumed by the Khasi tribals have always been harvested wild and no effort has been made to cultivate these varieties on a commercial scale. With growing urbanisation, and changes in the food habits accruing due to it, the ancient tradition of gathering and consuming wild mushrooms by the local Khasi tribals is slowly on the decline. The high nutritional quality and unique flavours of these mushrooms

are likely to be lost if these wild edibles are not documented. Therefore it is now imperative that a nutritional database of these mushrooms is set up to retain the information on these unique species. Studies are also required on the content of anti-nutritional and toxic factors in wild mushrooms to establish their nutritional supremacy.

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